

LANDSAT BROWSE GENERATION  
USING WAVELETS FOR IMAGE REDUCTION

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This is a documentation contains information on the research I have done on browse generation. This documentation mainly goes over how a person can run wavelets algorithm, perform benchmarks, information on where to get the files on a system, point of contacts for use of systems and benchmark results.

Wavelet Code

I would like to first explain that the code for the wavelets algorithm was given to me by Aerospace engineering. Point of contact is Steve Galssman 301-286-4843. The technical person behind the wavelets algorithm is Jamie Milstein 310-336-2310. Jamie's e-mail is milstein@courier1.aero.org. There is a software example of the algorithm on disk from that aerospace along with documentation I have given this to Cliff Lui at CSC 794-2465.

I took the example provided by aerospace and converted any sections not in "C" into C. This makes the code portable, and I then added the timing functionality. I have also attempted to optimize the code by replacing "while loops" with "for loops" and getting rid of redundant code. I have added calls to read from a file and write to a file throughout the program and added a report file. This is to get a hard copy of timings, as well as, to run several benchmarks at one time. To run the benchmark you must have 4 files: a sample image file (know the dimensions of the image i.e. 512X512), the program known as landsat.c, (it has a header file called header.h to run), the header file itself and a Makefile.

### Where to Test

The benchmarks I have been running is on the SGI machine "Challenge" (known as class6c at sewp bowl). The IP number is 128.183.31.74 . The user id I am using is evalenci. You may contact Emilio Valenci for the password 286-2587. The system administrator at sewp bowl is Dan Winger 286-7658. He is helpful if you need to get an account or need to use the machine. The command used to print only postscript files on their machine is `lpr -Pmicrotek <filename>`. To print regular ascii files your environment must have the path for pps, the command is `pps <filename> | lpr -Pmicrotek`. The program files are in `~evalenci/lizz/WAVELET` directory. To run you simply type `l7` ( the makefile will tell you this).

In `~evalenci/lizz/DEMO/` are the original files that aerospace has sent. In `~evalenci/lizz/PICS` are a few of the landsat images I have been benchmarking. They are in seperate directories by territory. In `~evalenci/lizz/XV/xv-3.00a` is the graphics editor that I downloaded from public domain. A copy of the tarred file that I retrieved from public domain is in `~evalenci/lizz/XV/xv-3.00a.tar` . To untar type `tar -xvf xv-3.00a.tar` . This will create a new directory `xv-3.00a` where you copy the `Makefile.std` to `Makefile` and type `make` to execute to the C source code to compile. Then you may type `xv`. It is important that you have your display terminal set. (On most Unix platforms command is `setenv DISPLAY <windowid>`).

### How to Run Benchmark

To run benchmark log onto "challenge" and go into `lizz/WAVELET` directory ; type `l7` and a user interface will appear. You will see a user interface screen. Be sure you have the path of the image that you wish to run wavelets on and dimensions of the image. The interface will prompt you for raw image file, output file, report file, X dimensions and Y dimensions, wavelet level and subsampling level. Each subsampled level is raised to the power of two to determine subsampling. For example if the user chose wavelet 2

subsampling 3 then we say wavelet reduced image twice. Each time wavelets ran, it reduces the image 1/16 of it's original. Subsampling was by 8.

### Bench Mark Results

The Benchmark I took, concentrated on running sampling by 2 and 4. This was chosen so it would not degrade image resolution and have adequate performance. Wavelet was chosen to run once and twice again because of the same reasons. Choosing a combination of each and deciding which one degrades resolution the least, is left up to the user. You may bring up the browse image after running wavelets on the desired hybrid.

Table 1. Hybrid Results.

| <u>X</u> | <u>Y</u> | <u>Hybrid F Size</u> | <u>New X</u> | <u>New Y</u> | <u>Wavelet</u> | <u>Subsample</u> | <u>Time</u> |
|----------|----------|----------------------|--------------|--------------|----------------|------------------|-------------|
| 5956     | 6967     | 2599064              | 1492         | 1742         | 1              | by 2             | 22.29       |
|          |          | 649766               | 746          | 871          | 1              | by 4             | 12.86       |
|          |          | 162628               | 373          | 436          | 2              | by 4             | 11.46       |
|          |          | 10378836             | 2979         | 3484         | 0              | by 2             | 12.71       |
|          |          | 2595580              | 1490         | 1742         | 1              | by 2             | 22.35       |
|          |          | 2595580              | 1490         | 1742         | 1              | by 2             | 14.52       |
| 5957     | 6967     | 10378836             | 2979         | 3484         | 0              | by 2             | 32.80       |
|          |          | 2599064              | 1492         | 1742         | 1              | by 2             | 22.19       |
|          |          | 649766               | 746          | 871          | 1              | by 4             | 13.15       |
|          |          | 649766               | 746          | 871          | 2              | by 2             | 22.00       |
|          |          | 648895               | 745          | 871          | 1              | by 4             | 13.59       |
|          |          | 649766               | 746          | 871          | 2              | by 2             | 20.74       |
|          |          | 648895               | 745          | 871          | 2              | by 2             | 20.94       |
|          |          | 162628               | 373          | 436          | 2              | by 4             | 12.43       |
|          |          | 162628               | 373          | 436          | 2              | by 4             | 14.04       |
|          |          | 162628               | 373          | 436          | 2              | by 4             | 10.93       |
|          |          | 10246                | 94           | 109          | 3              | by 8             | 12.06       |
|          |          | 10246                | 94           | 109          | 3              | by 8             | 11.53       |
|          |          | 10246                | 94           | 109          | 3              | by 8             | 11.90       |
|          |          | 10246                | 94           | 109          | 3              | by 8             | 11.98       |

Note. Inputed FileSize: 41558155 (bytes),41558155 (bytes). For file Sizes all are in bytes. If Scene and Files are repetative is because ured from different Landsat image.

Based on findings by aerospace, they had suggested that hybrid of subsampling-by-4 followed by 2 wavelet iterations or subsampling-by-8 followed by two iterations of wavelets shows best results. Given the time constraint (run under 23 seconds), I determined that the algorithms best performance and resolution would be to use subsampling by 4 and running wavelets twice. The above has the following averages:

Table 2. Hybrid Averages.

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|                              |       |
|------------------------------|-------|
| Wavelets 2 subsampling by 4: | 12.60 |
| Wavelets 2 subsampling by 8: | 11.86 |
| Wavelets 1 subsampling by 2: | 20.3  |
| Wavelets 1 subsampling by 4: | 13.2  |
| Wavelets 2 subsampling by 4: | 21.2  |

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#### Graphics Tool Kits

To determine if wavelets ran properly I needed to view the browsed image. I used a software package known as "Image tool". Division 920.2 in Build 22 has this package. You may contact Penny Masuka 286-3866. This software sold by PCI is very diverse and easy to use. I had contacted the vendor Ed Jurkevics (703) 243-3700 or [jurkevics@pci.on.ca](mailto:jurkevics@pci.on.ca) . I have received a demo it is on cad564a in my directory ~lizz/PCI . The following packages were looked at:

xli - will load gif,tif,bmp,sunraster files. It needs a converter to change the image into one of these types.

xv - Works the same way as xli this software however has a more friendly GUI interface for printing and moving/editing images around. It also supports IRS raw images.

imagetool - Works only with openwindows. This software was said to be able to load up raw data, but I have yet to be able to do this.

There are two convertors have looked at:

frombin - is a command found in all SGI OS systems. Basically it takes rows and columns and converts into data readable by any format desired. I have this working in conjunction with xv on the SGI "challenge".

pbmplus - let you convert a raw image into an internal pbm image then from the internal pbm image into any type of image format desired.

Most of these software packages were/can be retrieved via ftp ftp.x.org. in directory /x11r5/contrib. You can also use gopher to get a listing of available sights: ftp gopher.msu.edu login as gopher.

References on Wavelets:

Waveform Analysis: Guide to Interpretation of Periodic Waves Including Vibration Records. By R.G Manley. Call no. QA403.M27

Ten Lectures on Wavelets. By Ingrid Daubechies  
Rutgers University of AT&T Bell Lab. Call no. QA403.3.D38 1992

Proceedings of Symposia in Applied Math vol47, Different Perspectives on Wavelets.  
American Math Society short courses Jan 11-12. Ingrid Daubechies Call no.  
QA403.3.D54

Progress in Wavelet Ananlysis and Application. By Y. Maeyer & S. Rogers.  
Call no. QA403.3.I57

Cambridge Studies of Advanced Math: Wavelets and Operators. By Yves Meyer. Call no.  
QA 403.3.M4913

Wavelets Algorithm & Applications. By John Benedetto and Micheal W. Frazie. Call no.  
403.W48 1994

Wavelets and Applications. By Mary Beth Ruskai, Gregory Beylkin, Ronald Coifman,  
Ingrid Daubechies, Stephane Mallot , Yves Meyer and Louise Raphad.

An Introduction to Wavelets. By Charles K. Chui. Call no. qa403.3.c48 1982